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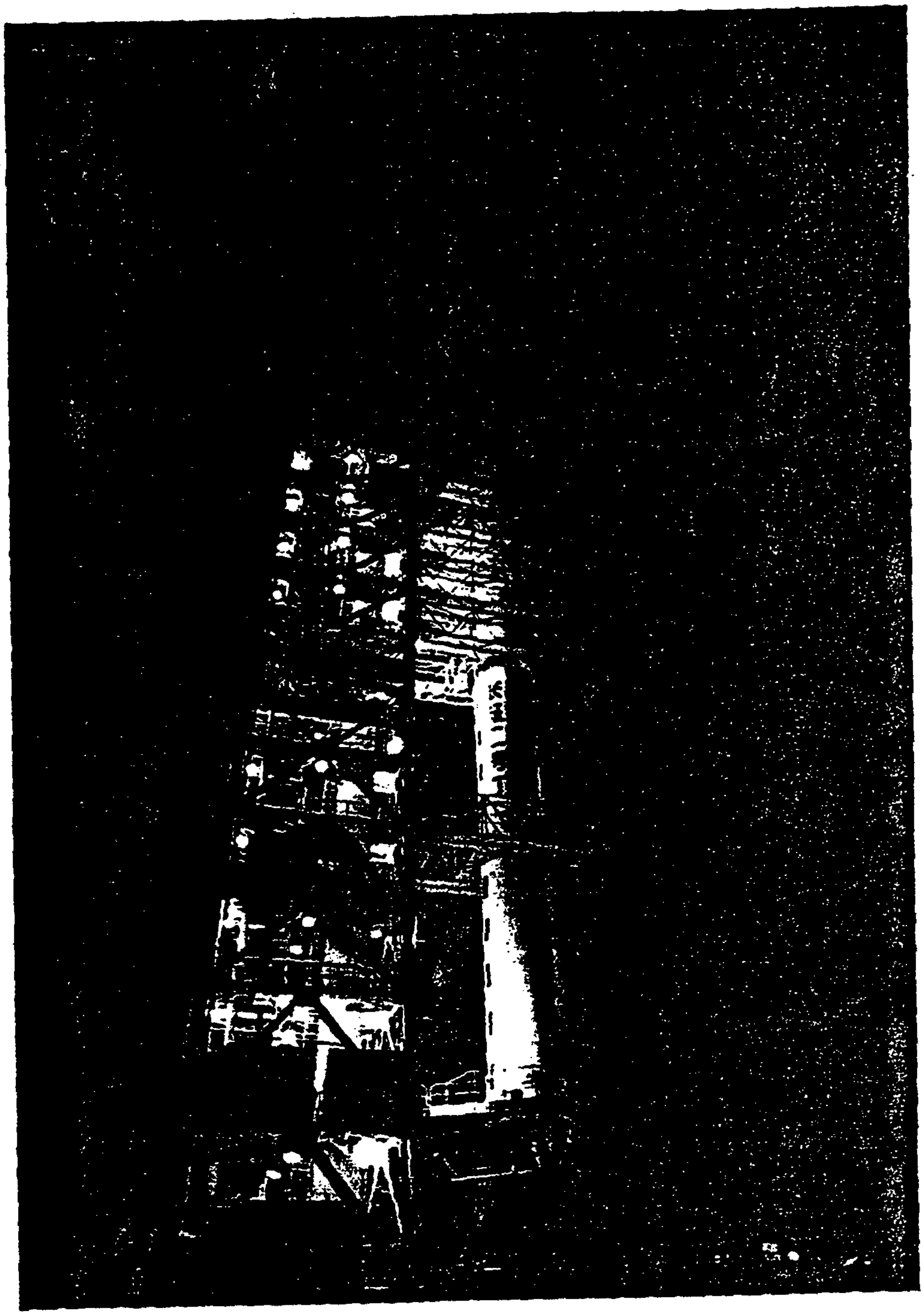

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CHINESE COMMUNICATIONS SATELLITES AND THEIR BENEFITS

Qi Faren Zhu Yilin

Translation of "Zhong Guo De Tong Xin Wei Xing Ji Qi Xiao Yi"; Aerospace China, No.3, March 1993, pp 3-5

In order to change the backward status of communications enterprises as fast as possible, after China's successful launch of its own first man made satellite, it then immediately began to develop communications satellite operations in order to realize pannational communications coverage which included in it hinterland regions, to complete television broadcasting for parts of provinces which will be equal to the large cities, to realize satellite broadcasting of Central People's Broadcasting Station programs to China domestically and abroad, and to resolve communications services associated with military communications, ships on the high seas, and survey ships.

EXPERIMENTAL COMMUNICATIONS SATELLITES

On 29 January 1984, China's first experimental communications satellite was sent into an orbit with a perigee altitude of 474 kilometers and an apogee altitude of 6480 kilometers using the Long March No.3 carrier rocket. In orbit, a series of satellite function tests was completed, including such tests as communications, attitude control and orbit control, telemetry control, antenna spin elimination, and so on. Results proved that the satellite design plan was correct. Satellite performance satisfied design requirements.

On 8 April of the same year, the second experimental satellite was launched. The satellite successfully entered into geostationary orbit, positioned in space over the equator at 125° east longitude.

The primary characteristics of the experimental satellites in question was as follows.

Satellite diameter was 2.5 meters. They had cylindrical bodies 3.1 meters high. Their take off weight was 900 kilograms. Weight in orbit was 461 kilograms. Silicon solar cells were glued to the outer surface of the satellites. They are capable of supplying 315 watts of output power. The satellites were designed for an orbital operating life of 3 years. The precisions with which set points were maintained in north south and east west directions were 1 degree in all cases.

Satellites carried 2 communications transponders. Radiated power was 8.0 decibel watts. Use was made of whole earth beam antennas. Maximum antenna reception gain was 19.5 decibels. Maximum transmission gain was 16.5 decibels. As far as communications frequencies are concerned, up links were 6225-

6425MHz. Down links were 4000-4200MHz. After the satellites in question were delivered into service in May of 1984, their operations were normal right through. The actual service life far, far exceeded 3 years.

Up to the end of 1991, besides experimental communications satellites, China also launched 5 operational communications satellites. The operational satellites were divided into 2 types. Dong Fang Hong-2 and Dong Fang Hong-2A satellites. Only one was launched of the former. 4 were launched of the latter.

DONG FANG HONG 2 AND DONG FANG HONG 2A OPERATIONAL COMMUNICATIONS SATELLITES

Dong Fang Hong 2 operational communications satellites and experimental communications satellites are basically the same in terms of configuration and performance. The only place where there is some difference is that the former use domestic beam antennas. The latter make use of global beam antennas. Thus, radiated powers at the center of beams increase to 10 decibel watts or higher. As far as reception of the television images originally transmitted from experimental communications satellites is concerned, the ground needed to use antennas with diameters of 10 meters. However, with regard to the Dong Fang Hong-2 operational communications satellite, it was then possible to receive images of the same clarity using antennas with diameters of 3 meters.

The antenna beam of the satellite in question covers the entire national territory of China. It is capable of providing effective communications services for such hinterland areas as Xinjiang, Tibet, and so on, as well as for border defenses, maritime defenses, external affairs, and so forth.

In April 1986, the Dong Fang Hong-2 satellite replaced experimental communications satellites in the carrying out of broadcasting services. In February 1987, it began to transmit 15 channels associated with the Central Peoples Broadcasting Station broadcast programming to the outside. In September 1987, this was increased to 30 channels. The satellite in question operated right on until 8 July 1989.

Dong Fang Hong-2A operational communications satellites are improved models of Dong Fang Hong-2. Their diameter is still 2.1 meters. Height has been increased to 3.68 meters. The weight of the satellites in orbit is 441 kilograms. They carry 4 C wave band communications transponder units. The equivalent omnidirectional radiated power is 36 decibel watts--3 decibel watts higher than the Dong Fang Hong-2 satellite. The accuracy of satellites maintaining their fixed points are ±1° in a north south direction and ±0.5° in an east west direction. /4

Attitude controls associated with the Dong Fang Hong-2A satellites opt for the use of spin stabilization. Their parabolic antennas, by contrast, opt for the use of mechanical connections to eliminate spin. On the outside surfaces of the satellites are glued over 20 thousand silicon solar cell panels in order to supply electric power.

DONG FANG HONG-2A AND DONG FANG HONG-2

In comparisons, the primary areas of improvement are that it carries 4 transponder units, increasing the number one fold. Output power is increased 25%. Satellite design life is extended to 4.5 years, which is 1.5 fold that for Dong Fang Hong-2. The Dong Fang Hong-2A satellites are capable of providing 3000 channels of telephone or 4 channels of television. However, the Dong Fang Hong 2 satellite only had 1000 channels of telephone or 2 channels of television. Speaking in terms of equivalent omnidirectional radiated power values, Dong Fang Hong-2A satellites are also 3 decibel watts higher than the leased International Communications Satellite No.5.

The first Dong Fang Hong-2A satellite was launched on 7 March 1988. It was fixed at a point in space above the equator at 87.5° east longitude. The utilization of the 4 transponders was distributed as follows. Transponders A and B were used, respectively, to broadcast program sets No.1 and No.2 of the central television station. Transponder C was used to broadcast Tibet television station programs and to supply various types of services for the Peoples Bank of China. Transponder D used time division modulation methods to broadcast programs associated with Yunnan, Guizhou, and Xinjiang television stations.

The second Dong Fang Hong-2A satellite was launched on 22 December 1988. It was fixed at a point in space above the equator at 110.5° east longitude. The 4 transponders were used, respectively, to transmit two sets of central educational television programs, 30 channels of programs broadcast abroad, and for special types of communications services.

The third Dong Fang Hong-2A satellite was launched on 4 February 1990. It was fixed at a point in space above the equator at 98° east longitude. From after completion of orbital test measurements and delivery into service until now, it has supplied good communications services right along.

The fourth Dong Fang Hong-2A satellite was launched on 28 December 1991. Due to the fact that, after the second iteration of ignition of the rocket's third stage, engines went out ahead of time, the satellite did not enter into the predetermined orbit. Through ground control, engines carried on the satellite sent it into a large elliptical orbit with an apogee altitude of 35176 kilometers. Various satellite systems operated normally. In conjunction with this, it was placed into the adjustment control of ground telemetry and control systems.

DONG FANG HONG-3 COMMUNICATIONS SATELLITE

China is in the midst of developing the Dong Fang Hong-3 intermediate capacity communications satellite in order to satisfy the requirements associated with domestic communications broadcasts and television programs, which grow day by day in the 1990's.

The Dong Fang Hong-3 satellite will carry 24 C frequency band transponders. Equivalent omnidirectional radiated powers are, respectively, 34 decibel watts and 37 decibel watts greater. Among these, 6 intermediate power transponders are used to transmit television. The rest of the transponders are used in transmitting telephone, telegraph, teletype, and data. Satellites are able to simultaneously transmit 8100 channels of duplex telephone and 6 channels of color television. Design life is 8 years.

The main body of the Dong Fang Hong-3 satellite is a 2.2x1.72x2.0 meter cube. When antennas are included in, the height is 5.71 meters. The wing span of two solar cell wings is 18.1 meters. The satellite take off weight is 2200 kilograms. The initial weight when entering into geostationary orbit is 1145 kilograms.

The satellite in question is composed of 7 subsystems--communications, structure, electrical sources, thermal control, attitude control and orbit control, propulsion, and telemetry control. Moreover, option is made for the use of the new technologies below.

Option is made for the use of full three axis stabilized attitude control systems, unified dual component liquid propellant systems and large surface area sealed grid solar cell arrays. Two solar cell wings are fixed toward the sun. After entering into orbit shift, they are then fully deployed. Initial operating output power is 2000 watts. Communications antennas opt for the use of dual grid dual parabola multiple feed source molded beam antennas and orthogonal linear polarized frequency isolated multiple use technology. Satellite structures opt for the use of high modulus, light weight, multiple layer composite materials. Configurations opt for the use of modularized designs.

Dong Fang Hong-3 satellite antenna beams are capable of covering 90% of the territory of China. Television channel equivalent omnidirectional radiated powers are greater than or equal to 37 decibel watts. Single ground receiving stations use antennas with 3 meter diameters to receive television programs transmitted by Dong Fang Hong-3 intermediate power transponders. The quality of received imagery can reach level 4.

As far as the utilization of these new technologies is concerned, it will make technology associated with Chinese communication satellites reach a new level.

The launching and application of Dong Fang Hong-3 satellites will be able to satisfy the requirements of the whole country for satellite communications before the year 2000. The satellite in question will become China's first satellite to implement commercialized management.

Development of the Dong Fang Hong-3 satellite depends primarily on China's own strength. Design and manufacture are by the Chinese Space Technology Research Institute. At the same time, certain components are also procured from abroad. In conjunction with this, Germany's MBB company has cooperated in the development of certain subsystems of the satellite in order to shorten the development period and raise the development level. The Dong Fang Hong-3 is the first satellite China has cooperated with foreign countries on. It will develop a step further the accumulated experience associated with international cooperation for China in the area of space technology.

BENEFITS OF CHINESE COMMUNICATION SATELLITES

Information transmission speed is one of the important factors influencing the development of such enterprises as economic construction, cultural education, and so on. In the past, Chinese communications broadcasting facilities were comparatively backward. In particular, long range communications. Not only was the number of channels small, but communications quality was bad, severely limiting the development speed of the national economy. Since having communications satellites, the face of China's communications broadcast enterprises has given rise to huge changes, thereby very, very greatly promoting the development of the national economy and cultural and educational activities.

Communications satellites have brought for China huge direct benefits and indirect benefits. Since the acquisition of communications satellites in 1984, such Chinese departments as postal and telecommunications, petroleum, mining, water conservancy, electric power, news, as well as the military, and so on have made use of satellites to carry out various types of applications such as telephone, telegraph, teletype, data, forms and tables, imagery transmission, and so on, in a first step toward changing China's communications enterprises--particularly, the backward face of long distance communications--resolving difficult problems associated with communications in outlying places. /5

In the area of television and broadcast transmissions, if use is made of traditional microwave relay trunk lines to realize television and broadcast coverage to 80% of the area of the whole country, it is estimated that it would require an investment of 2 billion yuan Renminbi. However, if use is made of communications satellites, then, the investment can be reduced 1 billion yuan.

At the present time, making use of operational communications satellites has already opened up 30 channels for broadcasts abroad, central television station program sets No.1 and No.2 and Tibet television station programs. In conjunction with this, using time division modulation methods, transmissions are made of Yunnan, Guizhou, and Xinjiang television programs.

Up to the present time, China has already set up over 30 thousand single receiver stations and over 100 communications ground stations associated with antennas having diameters larger than 5 meters--thereby very, very greatly improving the quality of television transmissions and expanding the television coverage area. The realization of satellite communications makes the development of Chinese communications, broadcasting, and television enterprises leap over the traditional development phases--actualizing coverage for the entire nation in one stroke. The Chinese broadcasting, film, and television ministry said in an evaluation that China's communications satellites--in broadcasting and the transmission of television programs--"play an unusually important role, becoming a key bridge for the hundreds of millions of people in the whole nation to understand in a timely manner the domestic and foreign political and economic situation, to acquire various types of information, to receive cultural education, and to invigorate cultural life--obtaining very great economic benefits and social benefits."

In the area of educational television, before 1983, the coverage rate for the central television station and local television stations was only around 33%. Due to influences received from geography and weather conditions, the quality of educational television broadcast was low. Results were poor. Now, through communications satellites, 30 hours of educational television programs are broadcast every day. By 1992, in the educational system of the entire nation, over 500 educational television reception and transfer stations, over 4800 single receiver stations, and 46000 image projection points have already been set up. The coverage rate has already reached over 83%. On the basis of sampling investigations by Chinese educational television stations, at the present time, the people who look at educational television programs are estimated to have already reached 30 million people. Over 1 million 200 thousand teachers have been trained.

In the areas of long distance telephone and telegraph, if use is made of traditional microwave relay trunk lines or coaxial cable, building a communications network to link all the provinces and capitals of autonomous regions of the whole country would require an investment of several billion yuan Renminbi. However, making use of communications satellites, it only requires, by contrast, 500 million yuan.

By 1989, such satellite communications stations as Beijing, Kunming, Lhasa, Urumqi, and the Nansha Archipelago were already constructed. Over 1500 public voice circuits were opened up, accounting for 6% of the total voice circuits between provinces. Over 300 specialized use voice circuits were opened up for such departments as petroleum, coal, water conservency, electric power, and so on. Beginning in 1992, China will also construct one after the other a large batch of medium scale satellite ground stations. When the time comes, it is possible to add 7000-8000 satellite telephone and telegraph lines.

In the financial and monetary areas, as far as making use of communications satellite dispatching of funds is concerned, it makes it possible to very, very greatly reduce funds in transit. On the basis of incomplete statistics, at the present time, there are approximately 50 billion yuan in transit in transmissions between various types of banks in China. The time enroute is 6 days. If it is possible to make use of high speed satellite funds transmission data, it will reduce the funds in transit by half. It will then be possible to add an average of 25 billion in liquid funds for the banks.

China already uses Dong Fang Hong-2A communications satellites to transmit monetary data for China's banks. In conjunction with this, a Beijing central station is set up as the center. Through satellites, a data network of 350 branch stations all over the country is connected together. Linking up contacts between the central Bank of China and level 1 branch banks, on a national scale, there has been partial actualization of such modernization as funds clearing and transformation, monetary management, service training, as well as television conferencing, and so on--at the same time, very, very greatly reducing funds in transit.

In the area of railroad transport, it is possible to make use of satellite communications and positioning systems to dispatch rolling stock, improving the density of traffic. For example, it is possible to take train departure time intervals and reduce them from the current 8 minutes to 3 minutes. It is, thereby, possible--in conditions where investments are not increased--to make transportation capabilities double. Between Beijing and Shanghai, the construction of a multiple track railroad requires an investment of 10.2 billion yuan. However, setting up a satellite communication system only requires approximately 1 billion yuan.

In summary, in the same way as pointed out in the evaluation that the Chinese postal and telecommunications ministry is just in the midst of, Chinese communications satellites "achieve important economic benefits and social benefits, playing a role of stabilizing the situation, reassuring people, and accelerating economic development with regard to outlying regions. The launching and utilization of Chinese communications satellites clearly show that China has already entered into the ranks of a small number of countries which are capable of designing and developing communications satellites on their own. The significance is great."

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RESEARCH ON MINIATURE SATELLITE COMMUNICATIONS SYSTEMS

He Ying (Trans.) Liu Junshan (Ed.)

Translation of "Wei Xing Wei Xing Tong Xin Xi Tong De Yan Jiu"; Aerospace China, No.3, March 1993, pp 23-26

I. GENERAL SITUATION

Due to the fact that geosynchronous satellites are able to act as fixed relay stations in space, as a result, their utilization actualizes satellite communications. However, there is only one geosynchronous orbit. Moreover, the number of satellites it is capable of holding is limited. At the present time, satellite communications are in the midst of developing in the directions of conversions to larger models and multiple uses. At the same time, in order to reduce satellite costs and extend their service lives, this then requires making satellite designs more and more complicated. Moreover, reliability requirements with regard to satellites are higher. On the other hand, geosynchronous satellite orbits are very high. Two way communication transmission time delays associated with satellites are extended. In order to compensate for this transmission defect, it is necessary to install large dimension antennas and high power amplifiers.

In order to avoid the problems that come along with the use of geostationary satellites, low earth orbit (LEO) satellites have received wide spread attention from people. A good number of organizations are in the midst of considering using LEO satellites. Due to the fact that LEO satellite link transmission losses are small, they are, therefore, capable of using small dimension antennas and low power transponders. The dimensions of satellites can also be reduced. However, compared to geostationary satellites, the time periods when LEO satellites are visible are subject to limitations. In order to improve satellite link utilization rates, it has already been proposed to develop multiple satellite systems--for example, the IRIDIUM system, the ORBCOM system, as well as the STARNET system, and so on.

Electronic mail systems which make use of LEO satellites actualize another path for satellite communications. However, between two areas with relatively large time differences, the use of real time communications is not appropriate. Nevertheless, it is possible to opt for the use of postal service systems to carry out communications. The systems in question are capable of carrying out data transmissions with 24 hours. LEO miniature satellite systems carrying storage and transmission functions are capable of very easily taking electronic mail services or facsimile data and transmitting it to a target location within 12 hours.

There is little risk in launching miniature satellites.

Costs are low. As a result, miniature satellite systems are not only suitable for use in communications and observation. They are, moreover, also appropriate for use in empirical space verification of new electronics equipment and communications systems. The advantages associated with miniature satellite network systems are as follows.

(1) Compared to geosynchronous orbit communications satellites, they possess comparatively low G/T and EIRP.

(2) They are capable of providing a simple global system possessing memory and transmission functions.

(3) It is possible to opt for the use of personal computers spread in various places all over the world to act as information collection ground terminals. Therefore, the costs of the system in question are very low.

(4) It is possible to effectively make use of currently existing designs to develop a type of small volume, light weight, low cost satellite fuselage.

(5) The space portion of the system in question is capable of being piggy back launched. It is also able to be launched by small model rockets.

(6) Due to low costs, miniature satellites are appropriate for use in empirical space verification of those new technologies associated with comparatively large risks.

Japan's communications research laboratories and Japan's NEC company are just in the midst of designing a type of miniature satellite digital information transmission system (see Fig.1) which possesses storage and transmission functions.

II. EXPERIMENTAL COMMUNICATIONS SYSTEMS ASSOCIATED WITH MINIATURE SATELLITES

1. Miniature Satellite Communications System Design

In order to make LEO satellites capable of supplying continuous communications, it is necessary to have 23 satellites distributed in 894 kilometer high orbits (see Fig.2). If it is a polar orbit satellite system, it is then necessary to have even more satellites because the polar regions require increased satellite distribution densities.

Giving consideration to differences in service objectives, it is possible to have various types of orbit and satellite distribution plans. In order to study the feasibility and characteristics of a simple type of satellite communications network, experimental systems include a certain number of miniature satellites. They are capable of providing communications between the surface and satellites as well as between satellite and satellite. The systems in question also opt for the use of storage and digital type information transmission repeaters. In systems, all the satellites are distributed in the same orbit. The orbital position that each satellite occupies is selected on the basis of principles which are capable of making the coverage range of this satellite connect up with the coverage ranges of the other satellites adjacent to it. Between various surface terminals within the coverage range region of this type of satellite, it is possible, through satellites, to carry out real time data and voice communications. At the same time, with surface terminals covered within the same time period by different satellites, it is possible, through satellite interlinks, to carry out real time communications. As far as data and voice transmissions carried out by surface terminals to the outside of satellite coverage areas are concerned, it is possible to make use of memory and transponder communications in order to complete them. /24

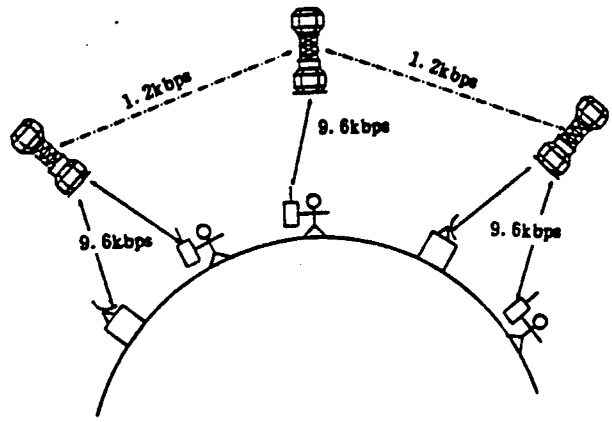

Fig.1 Experimental Satellite Communications System Diagram

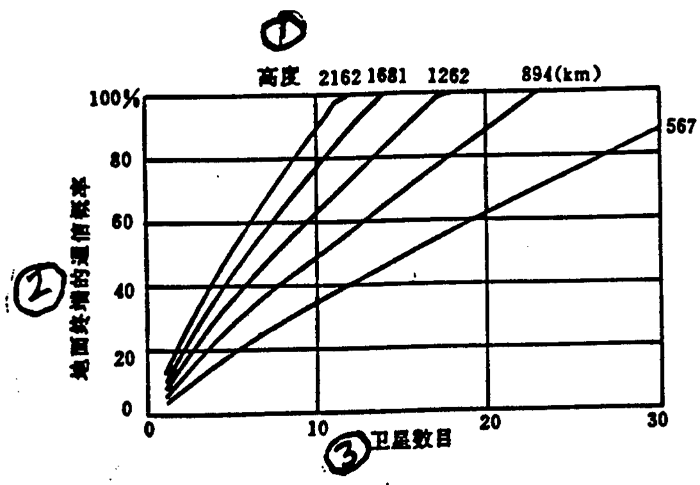

Fig.2 Surface Terminal Communication Probabilities
Key: (1) Altitude (2) Surface Terminal Communication Probabilities (3) Satellite Number

Opting for the use of methods associated with deploying many miniature satellites in one orbit, it is possible to expand real time communications ranges. Satellite communication time periods are also extended.

Table 1 is the relationships between the times when satellites are visible and satellite altitudes. Table 2 sets out the status of signal transmissions associated with satellite up and down links as well as intersatellite links.

Data transmission speeds between ground terminals and satellites are 9.6kb/s. Data transmission speeds between satellites are 1.2kb/s. Because satellite antennas must cover ranges of the earth's surface with large areas, antenna gains are reduced. In order to reduce transmission losses, up and down links should opt for the use of 400MHz frequency bands. However, intersatellite links are capable of making use of high gain satellite antennas.

Table 1 Total Operating Times

Altitude (km)	Time (Min)		
	Satellite 1	Satellite 2	Satellite 3
567	20	35	50
894	34	56	82
1262	55	84	113
1681	68	105	146
2162	105	171	241

Table 2 Status of Signal Transmission Between Satellites

Altitude=1681km

Links (Up/Down)	Surface/ Sat.1	Sat.1/ Sat.2	Sat.2/ Sat.3	Sat.3/ Surface Station
Frequency	400MHz	2.5GHz	2.5GHz	400MHz
Tx Power (dBW)	3941	4007	4007	3941
Feed Elec. Loss (dB)	0.5	1.5	1.5	0.5
Tx Antenna Gain (dBi)	0	8	8	0
Path Loss (dB)	156.4	171.3	171.3	156.4
Rx Antenna Gain (dBi)	3	8	8	3
Feed Elec. Loss (dB)	0.5	1.5	1.5	0.5
Rx Power (dBW)	-154.4	-158.3	-158.3	-154.4
Noise (dBW/Hz)	-203.8	-203.8	-203.8	-203.8
C/No(dB/Hz)	49.4	45.5	45.5	49.4
Required Eb/No(dB)	8.3	7.8	7.3	6.8
Bit Rate (kb/s)	12.9	5.9	6.6	18.2

2. Surface Station Radio Links

Surface stations are miniature mobile terminals. They opt for the use of omnidirectional antennas with gains of 0dB. Satellite orbit altitudes are approximately 1000 kilometers. With angles of elevation of 5° of more, it is possible to carry out radio link transmissions. Option is made for BPSK type modulation. If there is a requirement for C/No ≥ 46.8dBHz, then 400MHz frequency band radio link EIRP ≥ 27.5dBW. 2.5GHz frequency band radio link EIRP ≥ 42.4dBW. In order to obtain the needed EIRP described above, it is necessary to have the conditions that follow.

One type of situation is	
Transmitter output power	30dBW
Feed Electrical Losses	2dB
400MHz Frequency Band Antenna Gain	≥-0.5dBi
2.5GHz Frequency Band Antenna Gain	≥14.4dBi

Another type of situation is	
Transmitter output power	33dBW
Feed Electrical Losses	2dB
400MHz Frequency Band Antenna Gain	≥-3.5dBi
2.5GHz Frequency Band Antenna Gain	≥11.4dBi

In that case, relying on the omnidirectional antennas on satellites in the 400MHz wave band, it is possible to realize radio link transmissions. Using 7 element miniature linear configured antennas on satellites, it is possible, in the 2.5GHz wave band, to carry out radio link transmissions. /25

Table 3 Radio Frequency Link Estimated Calculations

Item	Case 1 (140MHz)		Case 2 (400MHz)		Case 3 (1.5GHz)		Case 4 (2.5GHz)	
	Up Link	Down Link	Up Link	Down Link	Up Link	Down Link	Up Link	Down Link
EIRP(dbW)	7.0	-2.5	7.0	-2.5	7.0	6.0	7.0	12.4
Commo Loss (dB)	-145.2	-145.2	-154.3	-153.4	-165.8	-165.8	-170.2	-170.2
G/T(dB/K)	-33.1	-24.0	-32.1	-23.0	-22.6	-22.0	-16.2	-22.0
Rx Antenna Gain (dBi)	-0.5	2.0	-0.5	2.0	8.0	2.0	14.4	2.0
Feed Elec. Loss (dB)	-2.0	-	-2.0	-	-2.0	-	-2.0	-
Rx Quantities (dBWHz)	-140.7	-145.7	-149.8	-154.8	-152.8	-157.8	-150.8	-157.8
C/No(dBHz)	57.8	56.9	49.2	48.8	47.2	46.8	49.2	46.8

3. Intersatellite Radio Link Transmissions

Links between nongeosynchronous orbit satellites possess the advantages below.

(1) Increasing the number of satellites, it is then possible to expand the direct communication area.

(2) Links between satellites in different orbits make it possible to reduce signal transmission times.

The output powers and antenna gains which the limited dimensions, weights, and powers of miniature satellites are capable of producing determine link signal transmissions. Moreover, the status of link signal transmissions also determines the possible transmission speeds.

Research personnel did studies with regard to two types of antenna arrangements. One type opts for the use of surface links to links between satellites and uses the same antennas. Another type is the installation of antenna arrays with 4 or even more elements in order to form a diffused state of radiation. Satellite orbits will also influence transmission speeds. The higher satellite altitudes are, the longer transmission ranges will then be, and the larger coverage ranges will be. Between two satellites with orbital altitudes of 1681 kilometers, when transmission power is 1W and antenna gain is 8dBi, transmission rates are capable of being 1.2kb/s.

Evaluations will be carried out of the feasibility and practicality of miniature satellite communications systems through communications technology empirical verification tests. During testing, it is necessary to give consideration to such problems as Doppler effects as well as satellite attitude and so on.

III. DESIGN PLANS ASSOCIATED WITH OVERALL SATELLITE SYSTEMS

In order to increase launch opportunities, satellite weights do not exceed 50 kilograms. Various satellite subsystems include electrical power source subsystems, attitude control subsystems, structural members, as well as mission subsystems (see details in Fig.3). The weight and power associated with the satellite body are, respectively, 32 kilograms and 8W. The weight of the mission section is 18 kilograms. Power is 27.6W.

The satellites in question opt for the use of JAS-1 miniature satellite bodies. They are satellites associated with dual satellite body structures of 26 sided solids. Between the two satellite body components, there is a connection by extendable rods. Solar energy cells are installed on external panels associated with each satellite body structure. After entering into LEO orbit, the extension rods spread out. The two satellite bodies are 2.5 meters from each other (see Fig.4). Structural dimensions of satellite bodies before they have spread out are a diameter of 440mm and a height of 2970mm.

The dual satellite body structure has the characteristics that follow.

(1) It is capable of having 2 spaces for placement of satellite born equipment. This conforms to the requirements associated with multiple uses.

(2) Structural strength is controlled by a central tube. The exterior structural form is capable of carrying out alterations

based on mission requirements.

In order to realize communications of surface station with satellite and between satellite and satellite, satellites opt for the use of three axis stabilization. Satellite antennas must aim at the plane of the earth (yaw plane) in order to realize radio links.

There are two types of methods associated with attitude control. One is to make use of momentum wheels to carry out active type attitude control. The other is to make use of gravity gradients associated with saturation body moments of rotation of transducers carrying moments of magnetic force or precision optical gyroscopes in order to carry out passive attitude control. If power losses associated with active type momentum wheels are too great, then option is made for the latter.

Table 4 Transmission Status of Links Between Satellites

Item		Data	
Altitude(km)	894	1681	2162
Frequency	S Wave Band	S Wave Band	S Wave Band
Range(km)	2558	4007	4801
Tx Power(dBW)	0	0	0
Feed Elec. Loss (dB)	1.5	1.5	1.5
Tx Antenna Gain (dBi)	8	8	8
Path Losses (dB)	167.4	171.3	172.9
Rx Antenna Gain (dBi)	8	8	8
Feed Elec. Loss (dB)	0.5	0.5	0.5
Rx Power (dBW)	-154.4	-158.3	-159.9
Noise (dBW/Hz)	-203.8	-203.8	-203.8
L/No(dB/Hz)	49.4	45.5	43.9
Required Eb/No(dB)	7	7	7
Bit Rate (kb/s)	17.4	7.1	4.6

/26

Satellite attitude control is applied by making use of gravity gradient moments of rotation. Stabilization axis vibration, which is also sway, is given rise to due to variations in solar irradiation and solar shadow, residual magnetic dipole moments of rotation, solar radiation pressure torque, and thermal expansion and contraction moments of rotation produced by gas pressure torque. Transducers associated with moments of magnetic force are capable of reducing sway.

IV. MINIATURE SATELLITE ANTENNA DESIGN

In order to install high gain antennas on miniature satellites, a new type of miniature rod shaped antenna was designed. Speaking in terms of S frequency band links between satellites, antenna gains need to be 8dBi or higher. Due to light antenna weights and their conformal angular maintenance structures, there is a need for miniature linear antennas associated with two elements. However, high gain antennas require miniature satellite surface areas that are large. Solar energy cell areas are reduced in response. As a result, a new type of miniature rod shaped antenna was designed, fitted with solar energy cells.

V. MEMORY AND TRANSMISSION REPEATER DESIGN

Repeaters are composed of radio frequency systems associated with up and down links of 400MHz and links between satellites of 2.5Ghz as well as memory/transmitter data control systems. In modulator/demodulators, application is made of digital information processing technologies. Besides this, modulator/demodulators opting for the use of conventional circuitry are prepared to act as back ups for TT&C systems.

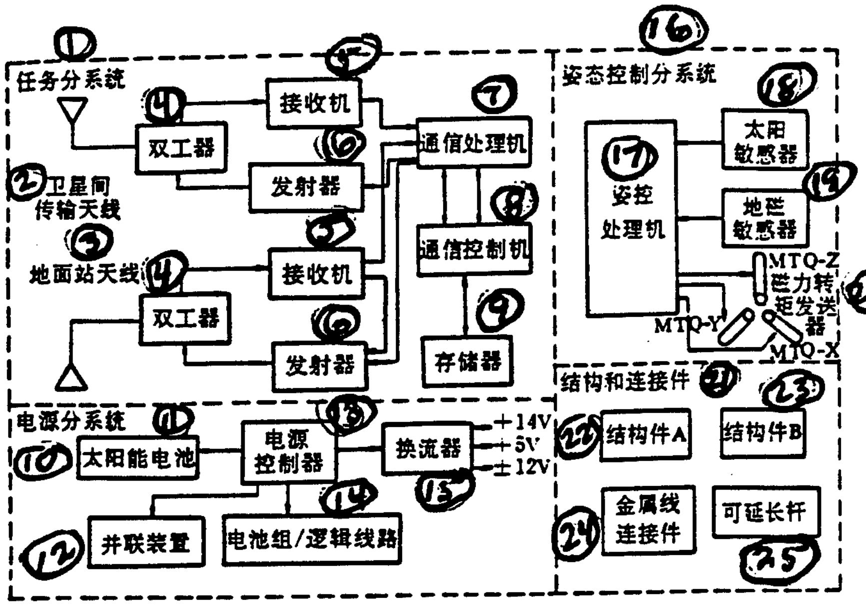

Fig.3 Satellite System Block Diagram

Key: (1) Mission Subsystem (2) Intersatellite Transmission Antenna (3) Surface Station Antenna (4) Duplexer (5) Receiver (6) Transmitter (7) Communications Processor (8) Communications Controller (9) Memory Device (10) Electrical Power Source Subsystem (11) Solar Energy Cell (12) Parallel System (13) Electric Power Source Controller (14) Battery/Logic Circuits (15) Converter (16) Attitude Control Subsystem (17) Attitude Control Processor (18) Solar Detector (19) Geomagnetic Detector (20) Magnetic Force Torque Transmitter (21) Structural and Connecting Members (22) Structural Member A (23) Structural Member B (24) Metallic Wire Connection Members (25) Extendable Rod

Memory/transmission systems are composed of microprocessors, data storage devices, and auxiliary circuitry. The systems in question are used in the keeping of information and data, the control of information transmission and reception, the receiving of satellite control commands, the transmission of telemetry data, and, in conjunction with that, the control of the pointing of 2.5GHz antennas. Memory storage device capacity is 4-16MByte. They are capable of storing 3 minutes of voice data with an encoding speed of 9.6kb/s. During tests, in order to find optimum transmission plans, it is possible to send out from ground stations commands in order to alter modulation methods and communications designs. Part of memory systems make use of dynamic memory integrated circuit modules for their manufacture in order, to the greatest extent possible, to raise memory capacity. In conjunction with this, the reliability of integrated circuit modules is checked in space.

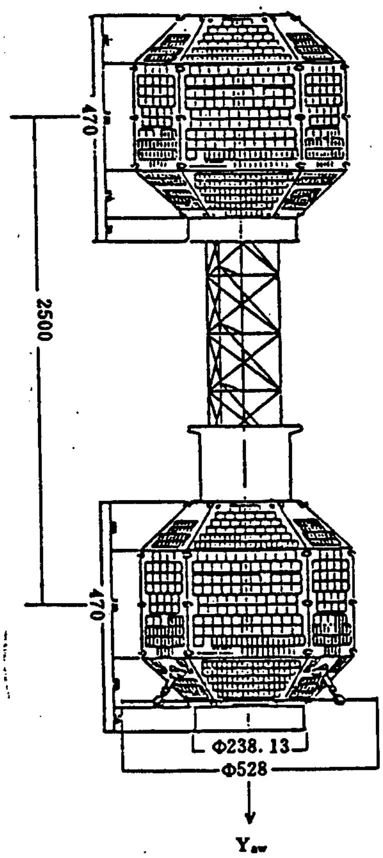

Fig.4 Exterior Structure of Miniature Satellite

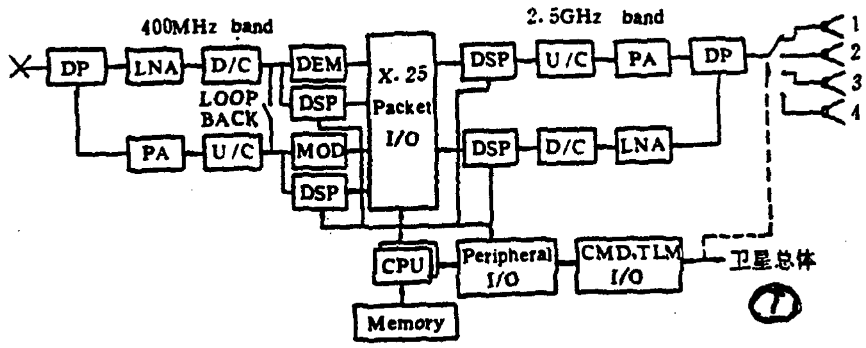

Fig.5
Memory/Transmission Repeater Schematic (1) Main Satellite Body

A NEW GENERATION OF SPACEFLIGHT RECONNAISSANCE TELEMETRY EQUIPMENT--IMAGING SPECTROMETERS

Zhang Wanzeng

Translation of "Xin Yi Dai Hang Tian Zhen Cha Yao Gan She Bei--Cheng Xiang Guang Pu Yi"; Aerospace China, No.3, March 1993, pp 27-28

Following along with the development of such modern sciences and technologies as survey technology, information recording technology, computer technology, as well as imagery processing technology, and so on, one new type of spaceflight reconnaissance remote sensing technology equipment--imaging spectrometers--is itching to have a try.

Imaging spectral technology is a new type of comprehensive survey technology which integrates imagery technology and spectral technology. Imaging spectrometers are products which combine in themselves imagery instruments and spectrometers. However, imagery technology and spectral technology are two types of techniques which are different in nature and category. Imaging instruments and spectrometers are two types of remote sensing instruments which are different in character. The former takes as its objective the obtaining of spacial images of target objects. The latter, by contrast, takes as its objective the acquiring of the physical characteristics of target objects. Before the 1970's, these two types of technologies and instruments developed independently and in parallel. Moreover, in technological terms, they were both already attaining maturity and perfection. In particular, optical imagery technology and optical imagery remote sensing instruments--through over 150 years of development--had already achieved a high degree of technical perfection. The characteristics of imaging spectrometers are such that they are not only able to acquire image information associated with target objects. They are also able to obtain spectral curve data corresponding to the target objects. The value of using them lies in simultaneously acquiring two types of information which are capable of complimenting and verifying each other. Again, adding together the high spacial resolutions possessed by imaging spectrometers and narrow spectrum diagnostic characteristics, classification and identification capabilities with regard to target objects are, thereby, very, very greatly improved, making the direct display of target object properties, identification of material constituents, as well as the amounts contained possible.

Traditional spaceflight reconnaissance remote sensing equipment is subject to constraints associated with the information carrier (for example, photographic film) and detection instrument technology (for example, CCD devices)--possessing such weak points as small spectral ranges, large wave band division widths, and low spectral resolution. Imaging spectrometers--in their combination of imaging instruments and spectrometers--overcome these weaknesses. They are able--within comparatively large spectral ranges from visible light to ultraviolet (0.70-0.40 microns) and from visible light to far infrared (0.70-2.25 microns)--to simultaneously acquire information associated with several tens to even several hundreds of continuous wave spectra and images--that is, they are capable, under a presupposition of satisfying certain surface resolutions and radiation resolutions, of also selecting ranges associated with even larger wave bands, even more numerous numbers of wave bands, and even higher spectral resolutions. Their introduction to the world is inevitable in the development of modern science and technology as well as remote sensing technology. There was another leap in imagery technology after the appearance of CCD imaging devices in the 1970's. As far as its development and the applications are concerned, they will make remote sensing technology and its applications give rise to revolutionary changes--taking spaceflight reconnaissance remote sensing and propelling it toward a brand new development stage. On the basis of expert predictions, at the end of this century and the beginning of the next century, imaging spectrometers will, together with imaging radars (SAR), play even greater roles in the realm of spaceflight remote sensing.

As far as the concept of imaging spectrometers is concerned, it was first put forward in the late 1970's by the U.S. Jet Propulsion Laboratory (JPL). In 1983, JPL developed the first airborne imaging spectrometer. In conjunction with that, the first flight tests were carried out on a C-130 aircraft. Using U-2 aircraft as remote sensing platform, even more advanced imaging spectrometers had already been completed in 1986. U.S. imaging spectrometer projects obtained support from the U.S. NASA. It was one of NASA's important high technology research and development projects in 1990. The final objective of this project's research was use in the Freedom space station and large model comprehensive Earth Observation Satellites (EOS). In cooperation with synthetic aperture radar, it will become the primary remote sensing detection equipment.

In terms of military spaceflight reconnaissance, imaging spectrometers have huge potential applications and broad prospects for development. The primary applications are as follows.

1. Providing for Spaceflight Reconnaissance Three Dimensional Imagery Information and Spectrum Directional Reflection Information, Thereby Improving the Interpretation and Identification Probabilities for Target Objects. This makes military target identification and classification develop from a planar (two dimensional) information analysis stage and a spectral and spectrum planar analysis phase to a new phase associated with a combination of three dimensional imagery information and meticulous and detailed spectral information.

2. Supplying a Basis for the Transformation from Qualitative Analysis to Quantitative Analysis for Intelligence Information. Up to now, the information acquired by spaceflight reconnaissance was

generally only able to satisfy qualitative processing and qualitative analysis of intelligence. Due to the fact that imaging spectrometers are capable of making full use of "meticulous and detailed spectral characteristics" associated with surface features as well as "narrow spectrum diagnosis characteristics" possessed by materials, the information obtained not only allows direct identification of the materials associated with surface features. Moreover, studies of the constituents of various types of materials as well as the amounts contained become possible. In terms of the processing and analysis of intelligence, this will be a great leap.

3. Revealing of Camouflage. The appearance of imaging spectrometers has provided an effective means of revealing camouflage associated with military targets and military facilities. In particular, with regard to situations where there are dazzling color camouflage as well as such weapons as missiles, tanks, artillery, and so on concealed in scattered woods in conjunction with which camouflage is applied, it is then possible to display the advantages associated with this comprehensive detection technology system.

4. Providing New Technical Means for Cruise Missile Flight Control and Guidance Technologies. Following along with the development of systems and their applications--in particular, with regard to situations associated with data obtained from front and back looking systems pointed toward the earth being completely transformed into full forward looking three dimensional observation imagery, and, in conjunction with this, the realization of real time imagery information processing--imaging spectrometers will act as an effective new method for cruise missile map matching guidance. Systems are also capable of providing forerunners for strategic bomber infrared forward looking three dimensional imagery. /28

5. Acquisition of Full Digital Three Dimensional Map Making Information. The full digital information which is acquired by imaging spectrometer three dimensional imagery systems--with the support of flight platform altitude data and precise positioning data--is capable of creating capabilities associated with full digital three dimensional computer map making--allowing the drawing up and production of maps to very, very greatly accelerate. Following along with increases in computer capacity and operational speed, rapid map making--even to the point of real time map making--becomes possible.

As far as imaging spectrometers are concerned--in such areas as natural resources, geology, environmental protection, as well as natural disaster monitoring, and so on--there are also broad prospects for applications and potential development.

SPACECRAFT LAUNCH SITE SAFETY PROTECTIVE TECHNICAL MEASURES

Zhang Yuchuan

Translation of "Hang Tian Qi Fa She Chang An Quan Bao Zhang Ji Shu Cuo Shi"; Aerospace China, No.3, March 1993, p 28

If it is desired to improve success rates associated with spacecraft launch sites, it is then necessary to pay serious attention to carrier rocket development quality and launch site safety.

For the last more than 30 years, in the areas of spacecraft and carrier rocket development and production, very great accomplishments have already been achieved. However, launch success rates still do not reach 100%. For example, the average launch success rate for carrier rockets in the West only reaches 91.7%. Although launch site equipment is improved continuously and levels of automatization also increase constantly, there still exist, however, unsafe factors. For this reason, it is possible to give rise to great fires, explosion accidents, propellant poisoning, and so on.

Despite the fact that launch operations have their risks, so long, however, as preventive measures are thorough, if danger is met with, there are preparations and not disasters. We will now talk a bit about unsafe factors associated with spacecraft launch sites and safety preventive measures.

I. WHEN ADDING PROPELLANT, IT IS NECESSARY TO HAVE RELIABLE SAFETY MEASURES

1. Control Fueling Speed

The speed with which propellant is added to missiles and carrier rockets (below, all called delivery vehicles) has a great influence on launch site safety. In particular, final stage fueling speed directly influences launch site safety. Excessive speeds will cause delivery vehicle tanks to deform and rupture. When propellant leaks meet with ignition sources, they will catch fire, directly threatening the safety of the launch site.

As a result, as far as adding propellant to delivery vehicles is concerned, there should be control of supplementations to speed. In the case of fueling speeds that are excessively great, propellant is very likely to exceed fluid levels. In regard to the thin walled containers associated with delivery vehicles--in particular, common bottom storage tanks--it is extremely dangerous. As a result, when fueling goes quickly to final fluid levels, it is necessary to lower fueling flow rates--at the same time, closing fueling discharge valves and safety overflow valves. When storage tank pressures show the appearance of abnormalities during fueling processes, pressures should be increased in a timely manner or fueling stopped, guaranteeing that delivery vehicle tanks will not rupture. Fueling is also not likely to lose by the delay.

2. Improve Fueling Precision

Launching a large model delivery vehicle requires several hundred tons of propellant with a need to take this propellant and reliably and accurately add it into delivery vehicle storage tanks.

At the present time, quantitative methods of adding fuel generally opt for the use of overall quantitative methods associated with "a fixed amount on the rocket and monitor on the ground". Once delivery vehicle tank surface indicators do not work, the basic amount of propellant added and supplemental amounts added are capable of being determined in amount by ground quantitative systems. This then requires improving the precision of the addition. At the present time, in technical terms, among the methods which use is primarily opted are included the following. (1) Make flow amount meters accurate to 0.1%-0.2%. (2) Opt for the use of antiexplosion fluid density sensors. (3) Opt for the use of semiautomatic and fully automatic fueling systems--normally opting for the use of microcomputers to carry out quantitative fueling and system control, reducing manual operating mistakes and the creation of errors.

3. Prevent Propellant Leaks

(1) Liquid Hydrogen Leakage and Control

Low temperature propellants liquid hydrogen and liquid oxygen are, at the present time, the comparatively advanced spaceflight propellants in use. Their main characteristics are high energy, large specific impulse, high exhaust gas speeds, and no pollution. The primary drawbacks associated with liquid hydrogen and liquid oxygen are that storage and transport are difficult, they have a strong tendency to leak, and there are many unsafe factors associated with them. Liquid hydrogen has a relatively low molecular weight and viscosity. Therefore, liquid hydrogen leaks very easily. When equipment ruptures or there is damage in such locations as fueling tubes, valves associated with liquid distribution pipes, and so on, large amounts of liquid hydrogen will leak out. In conjunction with this, it gasifies rapidly and diffuses into the atmosphere. The dangers appear primarily in two areas. One is causing people to suffocate. The reason is that liquid hydrogen leaked into unventilated, sealed spaces will make the air rapidly dilute. When the oxygen content in air is below 13%, it will then cause people to suffocate. The second is the formation of combustible or explosive mixtures. Once they meet with ignition sources, they are then capable of giving rise to combustion or explosion. After leaked hydrogen and air mix and the volume of hydrogen contained is in a range of 4% to 75%, combustion is then possible. With ranges of hydrogen contained between 18% and 59%, explosions are possible under appropriate conditions.

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Translation of [Unknown]; Aerospace China, No.3, March 1993, p 23

[Incomplete]

V. CONCLUSIONS

In the realm of spaceflight, infrared technology possesses broad prospects for development. On a foundation of further development in such technologies as infrared imagery, spectral identification, photoelectric composites, and so on, and, in conjunction with that, the achievement of extensive applications, imagery technologies associated with many wave bands (including ultraviolet, infrared, millimeter wave, and microwave) will be the direction of development of infrared technology in the systems area. It will become a new cutting edge science and stand on the leading edge of photoelectric technology. During the process of infrared focal plane array detectors entering into mature applications, intense competition between tellurium cadmiun mercury and multiple quantum trap super crystalline lattice devices is unavoidable. In accordance with analyses of the two at the present time, they are still not completely capable of replacing each other. At the same time, because of such strong points as low cost, good uniformity, structural simplicity, and so on, silicide detectors will achieve the advantages of broad applications. Indium antimonide, lead sulfide, and lead selenimide detectors--following focal plane technology breakthroughs--will also achieve new applications.